1990

Automobile Testing in the Toronto Area

Donald H. Stedman
University of Denver

Gary A. Bishop
University of Denver, gabishop10@yahoo.com

Automobile Testing in the Toronto Area

Publication Statement
Public Domain

May 7th, 1990

AUTOMOBILE TESTING IN THE TORONTO AREA

Donald H. Stedman
Gary A. Bishop
University of Denver
Department of Chemistry
University Park
Denver, CO 80208-0179
(303) 871-2580/2584

ATTENTION: Tony O'Donahue
City Council
Toronto, Ontario
CANADA

UNIVERSITY OF DENVER

Introduction

With support from the City of Toronto and the Ontario Ministry of the Environment (MOE), the University of Denver Fuel Efficiency Automobile Test device was set up at the entrance ramp from Bayview extension to the northbound Don Valley Parkway. The FEAT device, which measures carbon monoxide (CO) emissions from all passing motor vehicles with low-level exhaust systems is fully described elsewhere (1,2). Figure 1 shows a diagram of the system to monitor CO. A video camera was included in the Toronto study.

The FEAT acronym arises because vehicles which emit large amounts of CO are not using their fuel efficiently. Tune-up will improve gas mileage, reduce CO emissions and reduce hydrocarbon emissions (1,2). Logistics support was provided by J. A. Pryer of the Traffic Engineering Section of the Toronto Department of Public Works. Calibration gas was provided by the Ontario MOE. Liquid nitrogen (required by the prototype, but not by the new versions under construction) was provided by Scintrex/Unisearch of Downsview Ontario.

Measurements were made Monday through Thursday, April 23-26 with setup on Sunday, April 22. On april 25 and 26, Perceptics Corporation of Knoxville, Tennessee were also present. The Perceptics device takes a video picture of the license plate and uses computer-based pattern recognition to read the alpha-numeric plate pattern into the database via an RS-232 link. The plates read by means of the Perceptics unit were written onto the computer database and onto the video picture with the rear of the vehicle and the emissions.

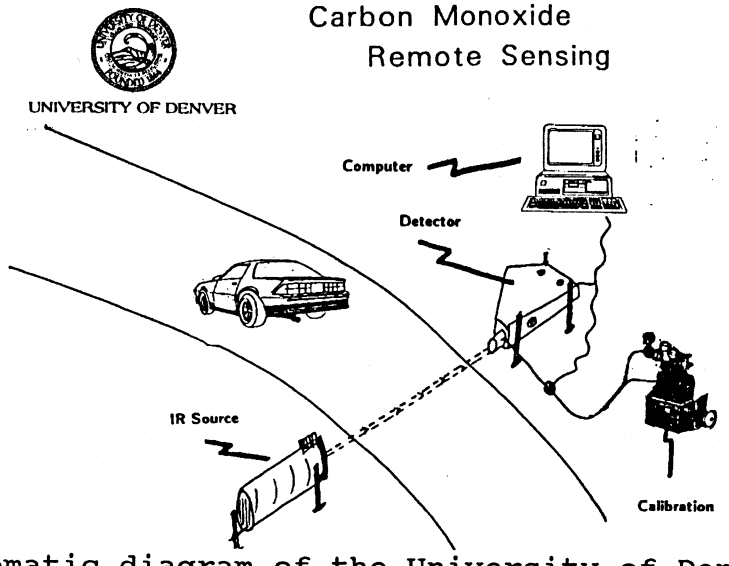

Figure 1: Schematic diagram of the University of Denver CO remote sensor.

Results, Fleet Emissions

The measurements were made using a control program with a half-second of data collected for analysis. The instrument was calibrated before each days measurements with a single gas cylinder containing a certified CO/CO_2 mixture. All of the daily measurements were scaled relative to this gas cylinder.

During the four days that the instrument was operational there were 12,071 blockages of the light beam followed by at least 0.5 seconds of non-blocked beam. The instrument records that event as a "vehicle count", although pedestrians and both the front and rear tires of large trucks are counted. Of these 12,071 counts, 228 were excluded as exceeding the preset confidence limits on the CO/CO_2 ratio and 553 were excluded because of the lack of sufficient exhaust to obtain a valid CO/CO_2 ratio. This resulted in 11,290 reported emissions measurements. Table 1 shows the results obtained for each of the days sampled and Figure 1 gives the overall distribution by vehicles and by total %CO emitted. Half of the CO was emitted by 8.03% (907 vehicles) of the vehicles with emissions above 2.86% CO. Only 4.36% of the fleet or 493 vehicles were measured above 4.0% CO. Compared to previous locations studied in Denver and Chicago this ramp has a much cleaner fleet (3, 4). Possible explanations for this distinction include a younger vehicle fleet (commuter fleets are usually newer cars) and/or better maintenance practices since fuel is more expensive and mechanics in Canada apparently require more extensive training than in the USA.

To understand the fleet more thoroughly it is possible to read the license plates from the FEAT video tapes and to determine the make/model-year distribution. With this data, it is possible both to determine whether the fleet is the same age as our other observed fleets, and to determine the rate of emissions deterioration. The FEAT video tapes are available at the University of Denver and contain data for approximately 7,000 of the total of 12,000 vehicle counts. If any agency is interested in reading the tapes they will need access to a super-VHS VCR and a high resolution colour monitor.

Results of Comparison to Perceptics

The Perceptics unit needs to be "trained" to read plates. It also has a narrower field of view than the FEAT video system. The best comparison data was obtained on the afternoon of Thursday, April 26 over a time period of about three hours. About half an hour of the videotapes have been analysed to obtain the statistics which will enable the program to be evaluated. The FEAT video tapes for 318 vehicles (336 vehicle counts) were read to compare perceptics computer-derived plates to those readable on the video tape. The results of this comparison are:

TABLE I					
%CO Category	Bloor/Bayview Ext. to N. Don Valley 4/23	4/24	4/25	4/26	Overall
<1	1903	2609	2503	1873	8888
1	227	269	283	246	1025
2	107	131	159	148	545
3	73	84	93	89	339
4	29	53	59	47	188
5	21	33	31	40	125
6	22	15	14	21	72
7	11	14	6	16	47
8	8	6	8	11	33
9	1	4	5	2	12
10	1	2	0	4	7
11	3	1	0	3	7
12	0	0	1	0	1
13	0	0	0	0	0
14	0	0	1	0	1
Totals	2406	3221	3163	2500	11290
Mean %CO	0.74	0.67	0.72	0.91	0.75
Standard Error	0.03	0.02	0.02	0.03	0.03

Total hits on FEAT tape	336
Readable plates on FEAT tape	280
Plates with Perceptics numbers	193
Plates with Perceptics six digit numbers	157
Correct Perceptics six digit numbers	148
Incorrect Perceptics six digit numbers	9

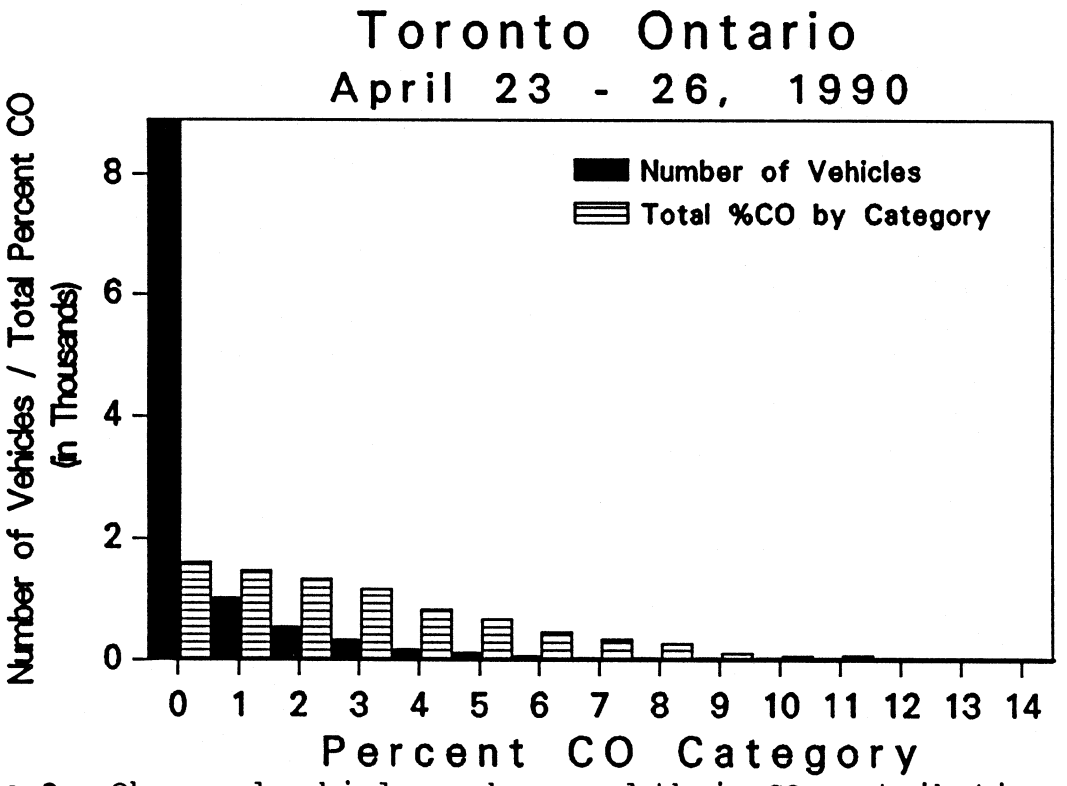

Figure 2: Observed vehicle numbers and their CO contribution. The solid bars represent the number of vehicles in each measured category (i. e. 0% is for 0% to 0.99% CO). The hatched bars represent the total sum of the %CO for each category.

The reason for separating the Perceptics data into six digit data and other data has to do with the field of view. Frequently the Perceptics unit could not see the whole plate, thus delivering a correct reading of five of the six letter/numbers. Other times when the whole plate was in view, sometimes only one letter or number would be read. There were several wheelchair plates which were not read correctly because the unit read the wheelchair as an O or a Q. The only other problems noted with the ability to read the letters and numbers was a B read as an 8 and several J's read as ones. It is possible that Perceptics did not train its software as to the shape of J used in the Ontario numberplate font.

Implication for Toronto

According to Messrs. Elliott and Wycliffe of Ontario Ministry of Transportation, the Province is considering the establishment of a vehicle Inspection and Maintenance (I/M) program. These programs are very expensive and (according to all the data I can lay my hands on) not very effective. They are not effective because all vehicles are inspected, although few fail, and because, at least in

the USA, the test has become, for some people, an annual challenge to "beat the test" rather than an annual commitment to keep the air clean.

We believe that remote sensing devices such as ours can enormously improve the cost-benefit aspects of an I/M program, especially when a hydrocarbon channel (underway) and an NO channel have been added. The NO channel is currently the subject of a research proposal to Ontario MOE from Rowan Williams and Co., Engineering, in Guelph, Ontario with subcontract to the University of Denver.

The goal of the City of Toronto to have cleaner air and improved on-road vehicle gas mileage can be met with the aid of a CO-only unit provided the results are acted upon. Unless the results are used, the testing itself carries no benefits. We have provided the new FEAT remote sensing tool. How the results are used is entirely up to the imagination of the legislators and administrators who have the new data. We have thought about some potential scenarios, but imagine that many others are possible.

1) Public Education

Set up no-penalty units. Advertise a free drive-through loaded-mode emission test (a $50.00 value). Use a big display to give the driver the reading as he/she drives away. Use a second big display to alert the dirty cars to pull over and pick up a free explanatory brochure. The brochure may point out:

Gas mileage improvement (as much as twice the %CO reduction)

Air quality improvement,

Safety improvement (many unfortunate fatalities are caused by inhaled vehicle exhaust)

2) I/M Programs

A combination of public stations, fixed stations (such as Bayview/Don Valley) and mobile remote sensors could be used to survey vehicles in the Toronto area. Even if Bayview/Don Valley were not fixed, Ontario Hydro might be persuaded to put in a few well-chosen 110v outlets for occasional City/Provincial use.

A single remote sensor will measure 2,000 to 6,000 vehicles per eight-hour day, depending on sighting. They work very well at night. Wet roads interfere significantly. From this, you can figure out how many it take to measure every vehicle in Toronto statistically N times per year.

The statistics are very important. Conventional I/M programs

are based on registration and idle testing. Remote sensing tests vehicles more often, the more often they drive, and is a more realistic emission test. It is also possible to focus the testing program on hot-spots if there are particular local pollution problems.

The administrative decisions which need to be made concern what to do with the results. Most vehicles are always clean (no action required). A few vehicles are always dirty (probably 2%). Some vehicles (perhaps 15%) are dirty sometimes and clean others. Criteria need to be established as to what vehicle readings merit what action.

Our prejudice is to look only for the few vehicles responsible for half the pollution. In Toronto, they will have readings greater than 4% CO. There is no need for any vehicle to ever be that dirty, even for peak power needs. In Toronto only a small fraction, less than one in thirteen at our site, will be above 3%. This means that a cost-effective program does not necessarily require the Perceptics plate reader. A small enhancement of the current FEAT unit would allow the pictures of the dirty vehicles only to be stored in digital cassette storage. After one day's work, 5,000 vehicles would have been observed. About 300 would have been put into digital storage. It would be easy to read these 300 into the MOT license plate database in less than half a day. The instant feedback which would be obtained would be very valuable since MOT would return the make/model-year information, and the reader would be asked to verify that the video picture indeed looked somewhat like the vehicle anticipated by the computerized license plate database.

The action to be taken based on the data is entirely at the option of the administrative entity. One possibility is all voluntary, i.e., mail out explanatory brochures with a picture of the vehicle. A second would be some sort of citation; for instance:

> "Your vehicle XYZ 123 has been observed twice to be a gross polluter. A tune-up could save your life, improve your gas mileage, and improve the air quality in Toronto. If you don't get cleaned up within thirty days, you will get a second notice requiring you to bring your car to the Ontario MOE Automobile Test Center."

If successful corrective action is taken on the fleet responsible for half the CO, then the CO reduction will be about 45% (50% becomes 5%). The hydrocarbon reduction based solely on CO correlation without a remote sensing HC channel would be about 35%. No-one knows yet how effective remote sensing-based programs may be for NO_x reduction.

The average %CO of a dirty car will be 5%. It will be tuned to less than 1%. Gas mileage (CO_2) improvement will be about 8%, but only for 7% of the fleet, i.e., an overall improvement of only a little over one-half percent. This looks pretty bad, but automobiles are one of the biggest single energy use factors. We know of no other way to improve the on-road fleet mileage. The estimates will increase to the extent that remote sensing targets high mileage vehicles. Other air quality improvement programs such as oxygenated fuels actually make fleet CO_2 emissions worse.

The Colorado Department of Health have suggested a "Clean Car" ticket program to supplement the current annual testing. If a vehcle were measured a few times as clean then they would receive in the mail a notification that they could register thier vehicle without taking it through the normal testing.

References

1. "IR Long-Path Photometry, A Remote Sensing Tool For Automobile Emissions," Gary A. Bishop, John R. Starkey, Anne Ihlenfeldt, Walter J. Williams, and Donald H. Stedman. Anal. Chem. 61, 671-A-677-A, 1989.

2. "Remote Sensing for Mobile Source CO Emission Reduction," D. H. Stedman and G. A. Bishop, Final Report under EPA Cooperative Agreement CR-815778-01-0. March 1990

3. "On-Road Carbon Monoxide Emission Measurement Comparisons for the 1988 - 1989 Colorado Oxy-Fuels Program", Gary A. Bishop and Donald H. Stedman, Environ. Sci. & Tech. in press, 1990.

4. "An Analysis of On-Road Remote Sensing as a Tool for Automobile Emissions Control", Donald H. Stedman and Gary A. Bishop, Report to the Illinois Department of Energy and Natural Resources, 1990.